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The stocks of spurdogs (*Squalus acanthias* L.) in British waters, and their migrations

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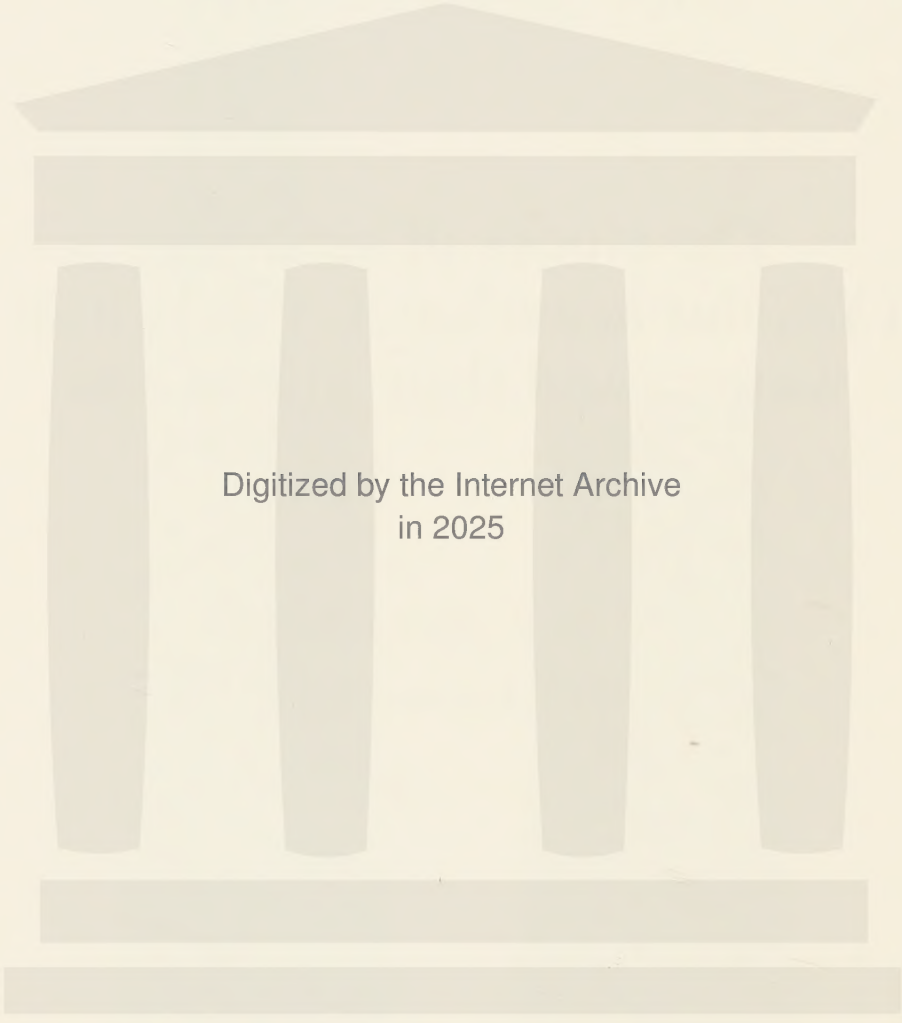

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The stocks of spurdogs (*Squalus acanthias* L.) in British waters, and their migrations

INTRODUCTION

THE spurdog is of considerable importance to English fisheries, although landings of dogfish by British vessels have declined steadily since 1951, from 12 712 tons, value £453 253 at first sale (Anon., 1952) to 4 223 tons, value £211 778 at first sale, in 1962 (Anon., 1963a). The major part of these landings consists of spurdogs but they also include small quantities of other species such as the lesser spotted dogfish, *Scyliorhinus caniculus* (L.), the greater spotted dogfish, *S. stellaris* (L.), tope, *Galeorhinus galeus* (L.), and miscellaneous sharks, none of which are separated in the landing statistics. In this paper such data will be referred to as 'dogfish statistics' and only referred to as 'spurdog statistics' when known to exclude all other species. In 1962, 85·1% of the total catch of dogfish by English and Welsh vessels was landed at Grimsby and Fleetwood, the bulk being caught by trawlers working the grounds off the north and west coasts of Scotland, and off the Orkney and Shetland Islands. Part of the landings at Grimsby come from an inshore line fishery that takes place off the Yorkshire, Lincolnshire and Norfolk coasts from June to October. In 1962, 77·4% (2 136 tons) of the total spurdog landings at Grimsby were trawl-caught and 22·4% (618 tons) line-caught, the remainder being taken by Danish seines.

The spurdog is known to make long migrations (Templeman, 1944, 1958; Kaufmann, 1955; Holland, 1957), and Aasen (1961, 1962 and 1963) has shown in extensive tagging experiments that there is a migratory movement between the Norwegian and Scottish coasts. There is also migration between the north of Scotland grounds and the Celtic Sea (Holden, 1962). In January 1958, fifteen spurdogs were tagged from R.V. *PLATESSA* off the mouth of the River Tyne, incidental to tagging other species. There were three recaptures from this liberation, one from the North Minch and another off Blyth (Northumberland), in the North Sea, both in November 1958, and a third off Flamborough Head (Yorkshire), in the North Sea, in July 1959. As a result of all these tagging experiments it appeared that there might be only one stock of spurdogs, which moved over the whole of the North Sea and round the north of Scotland into the Irish Sea, and that the trawl and line fisheries were both supported by the same stock of fish. More extensive tagging experiments were therefore planned to test this hypothesis, because it was essential to determine the number of stocks of spurdogs that existed, before population assessments could be made.

TAGGING EXPERIMENTS

THE NORTH OF SCOTLAND TRAWL FISHERY

Tagging cruises

IN June and July 1960, during cruises IX and X of R.V. *SIR LANCELOT*, 1 438 spurdogs were tagged in this fishery, and in June and July 1961 a further 3 822 spurdogs were tagged during cruises X and XII of R.V. *CLIONE*. The positions of release, by statistical rectangles, are shown in Figure 1. The length-frequency distributions of these fish are shown in Table 1; in this paper all measurements refer to total length of the fish. In 1960 four types of tags were used: Petersen discs attached to the base of the first dorsal fin, yellow polythene flag tags on braided nylon bridles attached through the musculature between the two dorsal fins, polythene flags treated with an antifouling mercury salt, on wire bridles, also attached through the dorsal musculature, and yellow polythene flag tags inserted into the body cavity. The highest rate of returns was obtained from Petersen discs, and in 1961 the majority of

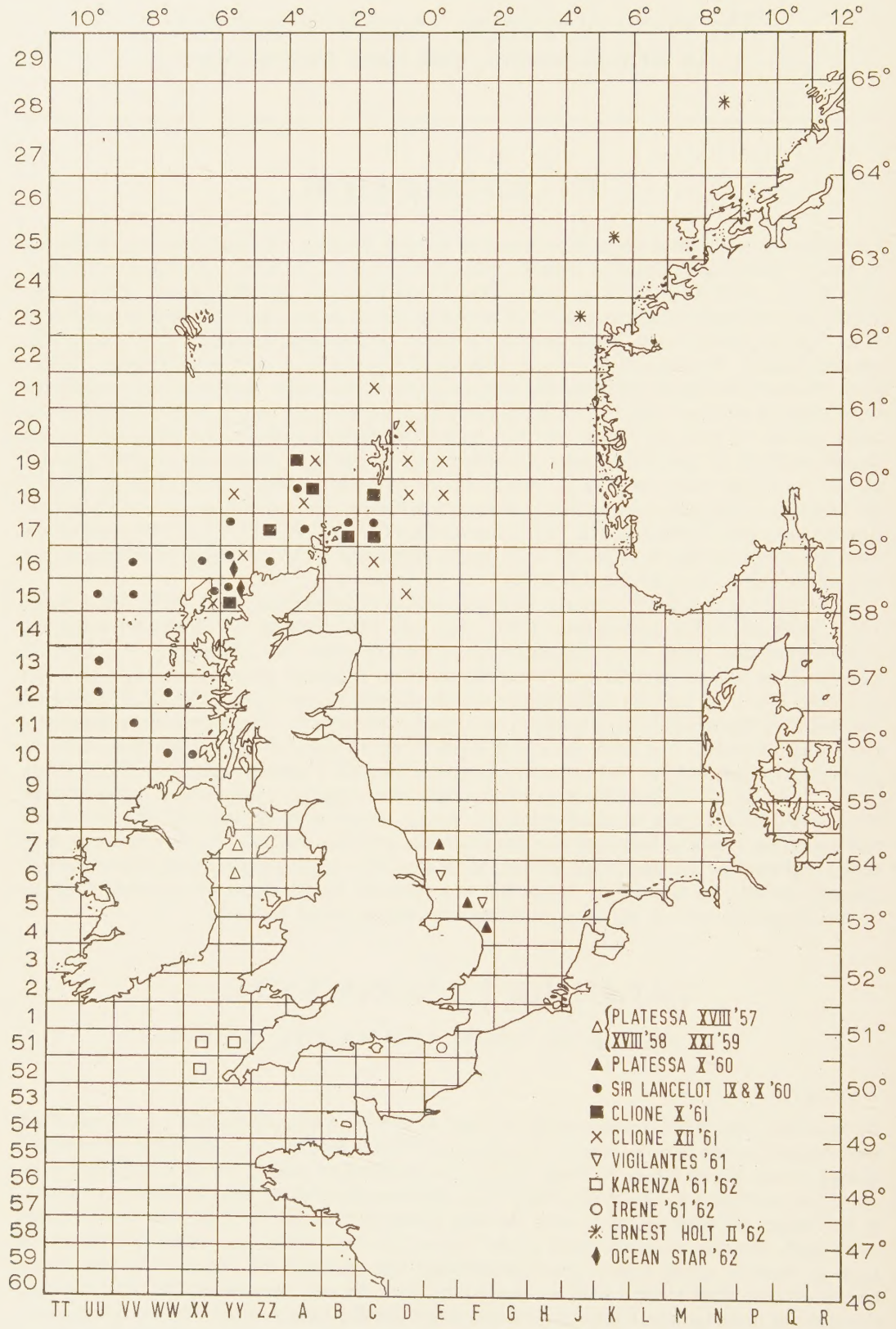
10° 8° 6° 4° 2° 0° 2° 4° 6° 8° 10° 12°
65° 64° 63° 62° 61° 60° 59° 58° 57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46°
TT UU VV WW XX YY ZZ A B C D E F G H J K L M N P Q R
PLATESSA XVIII '57
XVIII '58 XXI '59
PLATESSA X '60
SIR LANCELOT IX & X '60
CLIONE X '61
CLIONE XII '61
VIGILANTES '61
KARENZA '61 '62
IRENE '61 '62
ERNEST HOLT II '62
OCEAN STAR '62

Fig. 1. *Positions of release of tagged spurdogs, by cruises and statistical rectangles.*

Table 1. *Length-frequency distributions of spurdogs tagged during cruises IX and X/1960 of R.V.* SIR LANCELOT, *cruises X and XII/1961 of R.V.* CLIONE, *and from M.V.* OCEAN STAR, *December* 1962.

Length group (cm)	R.V. *Sir Lancelot* IX and X/1960			R.V. *Clione* X/1961			R.V. *Clione* XII/1961			M.V. *Ocean Star* December 1962	
	♀	♂	?	♀	♂	?	♀	♂	?	♀	♂
25–29	3										
30–34	8	10		2	1						
35–39	65	61		4	3						
40–44	117	86	1	8	15		3	6			
45–49	163	133		24	21		15	18			
50–54	130	132	1	98	84		26	22			2
55–59	59	75		341	278		46	30	2	3	2
60–64	37	37		406	456		25	42		3	22
65–69	8	62	1	163	424		7	65		2	238
70–74	11	63	1	35	278		5	196		1	888
75–79	14	19		52	119		4	72			713
80–84	28	3		114	11		2	8			125
85–89	47			182			2			1	4
90–94	44			162						3	
95–99	16			39						1	
100–104				2							
105–109											
?	1	2			1	2	1				
Total	751	683	4	1 632	1 691	2	136	359	2	14	1 994

fish were tagged with these, only small fish being tagged with polythene flags on braided nylon bridles. No definite size limit was set above which Petersen discs were used, but this was approximately 60 cm.

During cruise X/1961 of R.V. *CLIONE* male fish were classed as to maturity, using the state of development of the claspers. Three stages were recognized:

(*a*) immature: claspers very small and thin, not reaching posterior edge of pelvic fins;
(*b*) maturing: claspers thickening, approaching but not extending beyond posterior edge of pelvic fins;
(*c*) mature: claspers thick, extending beyond base of pelvic fins.

In December 1962, 2 008 spurdogs were tagged, using Petersen discs only, in the North Minch from the commercial seiner M.V. *OCEAN STAR*. All except fourteen of these were mature male fish, the remainder being female. The length-frequency distribution of these fish is shown in Table 1.

Returns of fish

The returns of fish to 31 December 1963 from all these cruises are shown in Tables 2, 3, 4 and 5. The returns have been grouped by regions, the key to which is given in Figure 2, and plotted by three-month intervals and by years. Period one includes the months March, April and May; period two June, July and August; period three September, October and November, and period four December, January and February. This grouping depends on the fact that spurdogs give birth to their young in December and January. In these tables male and female fish have been shown separately; also, for cruise X/1961 of R.V. *CLIONE* (Table 3) the returns of female fish have been tabulated in two groups, those from fish of 80 cm and less, when tagged, and those from fish 81 cm and longer. This corresponds to the 50% maturity point of female fish (Holden and Meadows, 1964). Those regions from which there were no returns have been omitted from the tables.

Table 2. *Returns of spurdogs tagged during cruises IX and X/*1960 *of R.V.* SIR LANCELOT, *tabulated by regions (see Figure* 2), *and by three-month periods: period* 1 = *March, April, May; period* 2 = *June, July, August; period* 3 = *September, October, November; period* 4 = *December, January, February.*

		Males											Females									
	Year	1960			1961				1962				1963	1960			1961				1962				1963
Region	Period	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
N.W. Scotland		2	2	1	1	0	1	0	1	0	0	0	1	1	2	0	1	1	1	0	0	0	1	0	0
N.E. Scotland		1	0	0	0	2	3	1	0	0	0	0	1	1	0	0	0	3	1	0	0	0	0	0	0
N. Norway coast		0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0

Table 3. *Return of spurdogs tagged during cruise X/*1961 *of R.V.* CLIONE (*details as in Table* 2).

		Males									Females 80 cm and less									Females 81 cm +								
	Year	1961			1962				1963			1961				1962				1963				1961				1962				1963			
Region	Period	2	3	4	1	2	3	4	1	2	3	4	2	3	4	1	2	3	4	1	2	3	4	2	3	4	1	2	3	4	1	2	3	4
Biscay		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Celtic		0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0
N.W. Scotland		2	7	7	9	1	1	5	4	0	2	0	3	2	1	3	0	0	1	1	0	0	0	7	4	3	5	2	2	1	0	3	1	0
N.E. Scotland		6	7	1	3	4	4	0	5	2	3	1	5	5	1	2	1	0	0	4	1	0	0	18	12	0	2	2	3	0	4	1	0	0
Viking		1	1	1	0	2	2	0	0	2	1	0	1	0	2	0	2	1	2	2	0	1	0	0	0	0	1	0	0	0	2	0	0	0
N. Norway coast		0	0	1	0	0	3	0	0	0	1	0	0	0	2	3	0	1	1	1	0	3	0	0	5	2	10	0	4	2	2	0	0	0
S. Norway coast		1	2	1	0	0	3	0	0	0	0	0	0	1	0	0	0	0	3	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0
Danish coast		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Skagerrak		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

One female fish, less than 80 cm when tagged, returned from 64°43′N 26°15′W (West of Iceland), October 1961.

Table 4. *Returns of spurdogs tagged during cruise XII/*1961 *of R.V.* CLIONE (*details as in Table* 2).

		Males											Females									
	Year	1961			1962				1963				1961				1962				1963			
Region	Period	2	3	4	1	2	3	4	1	2	3	4	2	3	4	1	2	3	4	1	2	3	4
Celtic		0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.W. Scotland		0	1	3	2	0	1	3	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
N.E. Scotland		2	2	2	1	1	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Viking		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
N. Norway coast		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
S. Norway coast		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 5. *Returns of spurdogs tagged from M.V.* OCEAN STAR (*details as in Table* 2); *male fish only.*

	Year	1962	1963			
Region	Period	4	1	2	3	4
N.W. Scotland		10	5	3	3	1
N.E. Scotland		3	5	5	2	1
Viking		0	1	1	3	0
N. Norway coast		0	0	0	2	0
S. Norway coast		0	0	2	1	0

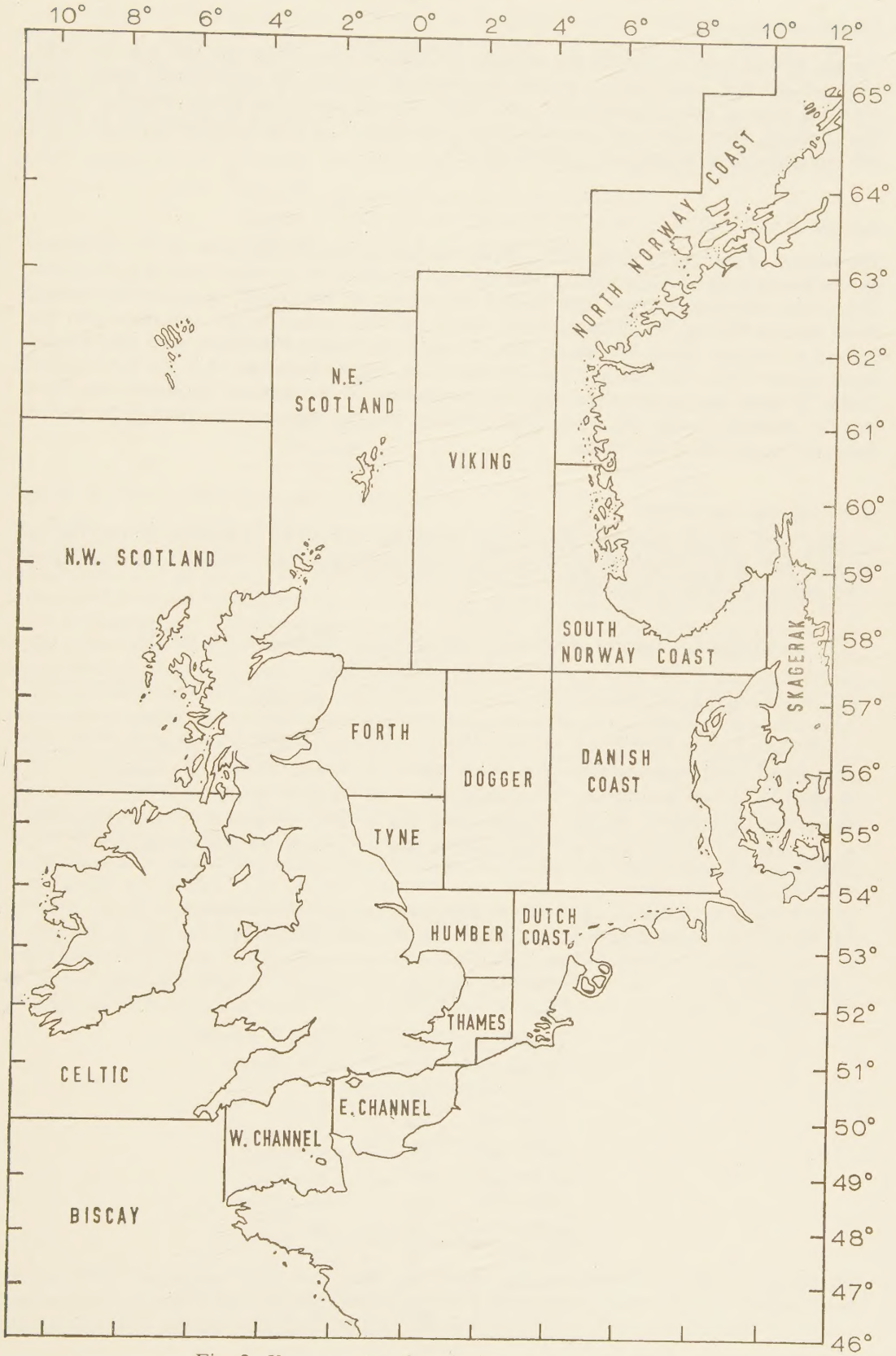

Fig. 2. *Key to regions by which returns are grouped.*

Returns of female fish

For the period June to August the majority of returns came from the two regions N.W. Scotland and N.E. Scotland but for the remainder of the year the returns were much more scattered, coming from regions as far apart as N. Norway coast and Biscay, with one return from Iceland. There is no obvious difference in the pattern of returns between fish of 80 cm and less and fish of 81 cm and longer (Table 3).

Returns of male fish

The pattern of returns of male fish is similar to that of female fish, most of the recaptures for the period June to August being from the two regions N.W. Scotland and N.E. Scotland. There were only four returns, from all five liberations, for the period December to January from regions Viking, N. Norway coast and S. Norway coast, which contrasts with the pattern of returns shown by female fish. As with the female fish there were also returns from regions Celtic and Biscay. The returns of fish tagged from the M.V. *OCEAN STAR* (Table 5) show that some of the male fish that winter in the north of Scotland area move rapidly eastward during the year, some reaching the Norwegian coast during the period June to August following release.

Other tagging experiments

In May 1959 fifteen spurdogs were tagged from the F.R.S. *EXPLORER* off the Faeroe Islands. The returns (Table 6) show that fish from this region move both to the Norwegian coast and to the west of Scotland.

Table 6. *Returns of spurdogs tagged off Faeroe Islands, May* 1959, *from F.R.S.* EXPLORER.

Release		Recapture		
Date	Position	Date	Position	Area
15 May 1959	61°33′N 05°55′W	2 January 1960	61°50′N 04°05′E	Norway coast
18 May 1959	62°33′N 06°14′W	11 March 1960	63°44′N 05°51′E	Norway coast
26 May 1959	61°54′N 07°45′W	24 December 1959	57°57′N 08°58′W	West of Scotland
26 May 1959	61°54′N 07°45′W	23 December 1959	62°30′N 07°30′W	Faeroes

Table 7. *Length-frequency distributions of spurdogs tagged during cruise II*/1962 *of R.V.* ERNEST HOLT.

Length group (cm)	Females	Males
60–64	2	1
65–69	6	1
70–74	19	1
75–79	54	2
80–84	146	2
85–89	292	0
90–94	200	0
95–99	62	0
100–104	18	0
105–109	6	0
Total	805	7

In February 1962 during cruise II of R.V. *ERNEST HOLT* 812 fish, whose length distribution is shown in Table 7, were tagged off the Norwegian coast. The returns of female fish from this experiment are shown in Table 8. They differ from the pattern of recaptures shown by other liberations in that there is little westerly movement during the summer to the north of Scotland area, there being ten returns during the period June to August from the Norwegian coast compared with only one from N.W. Scotland. For the period September to November the pattern is similar to that of the earlier experiments.

Table 8. *Returns of spurdogs tagged during cruise II/1962 of R.V.* ERNEST HOLT *(details as in Table 2); female fish only.*

	Year	1962				1963			
Region	Period	1	2	3	4	1	2	3	4
N.W. Scotland		1	1	0	1	2	0	0	0
N.E. Scotland		2	0	7	1	1	0	0	0
Viking		0	0	0	2	1	0	0	0
N. Norway coast		5	8	6	1	4	0	0	0
S. Norway coast		1	2	2	0	1	0	0	0

Returns of tagged fish in relation to fishing effort

To obtain a true pattern of migration recapture data should be presented in terms of catch per effort, but owing to the nature of the fisheries this is not possible. The north of Scotland grounds are worked mainly by Scottish seiners, English trawlers and Norwegian liners, the seiners and trawlers throughout the year but with varying intensity, the liners mainly from April to September. The Norwegian coast is worked almost entirely by Norwegian line vessels, the main fishery extending from October to March. During the rest of the year fishing for spurdogs continues along the coast, but the effort is very much less than during the winter months. Effort data are available for trawlers and seiners, but not for liners. The situation is further complicated because spurdogs shoal by sexes (Ford, 1921; Hickling, 1930), the mature females being found mainly in unisexual shoals, as during cruise II/1962 of R.V. *ERNEST HOLT*, while mature males, immature males and immature females are often found together, as occurred off Fair Isle during cruise X/1961 of R.V. *CLIONE*. At other times mature males form almost exclusively unisexual shoals; these were found in the North Minch during the tagging experiments from the M.V. *OCEAN STAR* in 1962.

At Grimsby the market will accept spurdogs of 40 cm and over, although few smaller than 50 cm are landed. The largest fish fetch the highest price, with the result that the trawlers fish those grounds on which they expect to catch large fish. Length measurements of Norwegian fish are not available, but the returns of tagged fish show that the female fish are preferentially sought, over twice as many female fish as male being recaptured. Testing the hypothesis that there is no difference between the recapture rates of the sexes gives a χ^2 value of 39·6, which is significant at less than the 0·001 level of probability (Table 9).

Table 9. *Returns of tagged spurdogs by Norwegian vessels, in relation to numbers of fish tagged; Petersen disc data only.*

	Male	Female
Number of fish tagged	2 238	1 954
Number of returns	46	114
% returned	2·1	5·8

$\chi^2 = 39{\cdot}6$ $P < 0{\cdot}001$ for one degree of freedom

In June 1961 Norwegian liners were only seen working those grounds on which large female fish were being caught by R.V. *CLIONE*. It is clear that more effort is exerted locating and fishing shoals of mature females, and that the distribution of returns is affected by this.

THE LINE FISHERY IN THE SOUTHERN AND MIDDLE NORTH SEA

Tagging cruises

In July 1960, during Cruise X of R.V. *PLATESSA*, 395 spurdogs were tagged in the line fishery off the east coast of England: the tags used were Petersen discs, polythene flags on braided nylon bridles, and polythene flags on wire bridles. In April and May 1961, one thousand spurdogs were tagged off Eastbourne from the commercial liner M.V. *IRENE*, in order to determine whether the fish that gave rise to the North Sea line fishery came from the English Channel. A further 890 spurdogs were tagged in the fishery off the Norfolk coast in the Dowsing area in August 1961 from the commercial liner M.V. *VIGILANTES*, and in April 1962 another one thousand spurdogs were tagged off Eastbourne, again from the M.V. *IRENE*. Petersen discs were used to tag all the fish liberated from the M.V. *IRENE* and from the M.V. *VIGILANTES*. The release areas for all these cruises are shown in Figure 1, and the length distributions, by sexes, of the tagged fish are given in Table 10.

Table 10. *Length-frequency distributions of spurdogs tagged during cruise X*/1960 *of R.V.* PLATESSA, *from M.V.* IRENE *in* 1961 *and* 1962, *and from M.V.* VIGILANTES *in* 1961.

Length group (cm)	*Platessa* X/1960		*Irene* 1961			*Vigilantes* 1961		*Irene* 1962	
	♂	♀	♂	♀	?	♂	♀	♂	♀
35–39		1							
40–44	3	4	1					2	
45–49	13	11	1						
50–54	24	11	3			1		1	3
55–59	35	43	9	3		5	2	4	10
60–64	32	55	34	18		20	15	22	24
65–69	28	22	105	56		25	34	134	44
70–74	39	22	220	94		21	98	328	57
75–79	26	10	85	84		7	184	187	35
80–84	6	7	7	114			217	8	36
85–89		1	1	80			170		52
90 94		1		56			68		32
95–99		1		22			20		13
100–104				5			3		2
105–109									3
?			1		1				2
Total	206	189	467	532	1	79	811	687	313

Returns of fish

The returns from these cruises up to the end of December 1963 have been tabulated in Tables 11, 12, 13 and 14, using the same method as for the other returns.

Returns of female fish

It is obvious from the recaptures of fish released from the M.V. *IRENE* off Eastbourne that the majority of these fish pass through the Straits of Dover to enter the summer line fishery in the North Sea (Tables 12 and 14). In 1961 fish 81 cm + in length showed a more northerly movement than those 80 cm and less (Table 12), but in 1962 the position was reversed (Tables 12 and 13). Seventy per cent of the returns during the period December to February were from the two regions W. Channel and E. Channel, while in the period

Table 11. *Returns of spurdogs tagged during cruise X/*1960 *of R.V.* PLATESSA (*details as in Table* 2).

		Males				Females			
	Year	1960	1961	1962	1963	1960	1961	1962	1963
Region	Period	2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
W. Channel		0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	1 0 0 0	0 0 0 0
Thames		0 0 0	1 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
Humber		2 2 0	1 3 0 0	0 2 0 0	0 0 1 0	4 2 0	0 1 3 1	0 4 3 0	0 0 0 0
Tyne		4 0 0	0 1 1 0	0 1 2 0	1 0 0 0	5 0 0	0 1 1 0	1 1 0 0	0 1 0 0
Dutch coast		0 1 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	0 0 1 0	0 0 1 0
Danish coast		0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 0	0 0 0 0	0 0 0 0	0 0 0 0
Dogger		0 0 0	1 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0	0 0 0 0

Table 12. *Returns of spurdogs tagged from M.V.* IRENE *in* 1961 (*details as in Table* 2).

		Males			Females 80 cm and less			Females 81 cm +		
	Year	1961	1962	1963	1961	1962	1963	1961	1962	1963
Region	Period	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
Biscay		0 0 0 0	0 0 0 0	1 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
W. Channel		0 0 0 0	0 0 0 1	2 0 0 0	0 2 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 1 0	1 0 0 0
E. Channel		3 0 0 0	0 0 0 1	2 0 0 0	3 1 0 1	2 0 0 2	1 0 0 0	0 1 0 0	3 1 0 2	0 0 0 0
Thames		1 2 0 0	2 2 0 0	0 0 0 0	0 8 3 0	2 1 0 1	0 1 0 0	3 2 0 0	5 4 3 0	0 0 0 0
Humber		0 8 6 0	0 7 2 0	0 1 0 0	0 6 6 0	0 3 2 0	0 2 0 0	0 10 8 0	0 1 2 0	0 1 0 0
Tyne		0 6 3 0	0 6 1 0	0 3 0 0	0 2 2 0	0 0 0 0	0 0 0 0	0 1 3 0	0 0 0 0	0 0 0 0
Dutch coast		0 0 0 0	0 0 0 0	0 1 0 0	0 1 0 0	0 0 1 0	0 0 0 0	0 0 0 0	0 0 1 0	0 0 1 0
Danish coast		0 0 0 0	0 0 1 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 0 0	0 0 0 0	1 0 1 0
Dogger		0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 1 0	0 0 0 0	0 0 0 0	0 1 2 0	0 0 1 0
N.E. Scotland		0 0 0 0	0 0 0 1	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
N.W. Scotland		0 1 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
Celtic		0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 1	0 0 0 0	0 0 0 0

Table 13. *Returns of spurdogs tagged from M.V.* VIGILANTES *in* 1961 (*details as in Table* 2).

		Males			Females 80 cm and less			Females 81 cm +		
	Year	1961	1962	1963	1961	1962	1963	1961	1962	1963
Region	Period	2 3 4	1 2 3 4	1 2 3 4	2 3 4	1 2 3 4	1 2 3 4	2 3 4	1 2 3 4	1 2 3 4
Biscay		0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	1 1 0 0
W. Channel		0 0 0	0 0 0 0	0 0 0 0	0 0 1	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0
E. Channel		0 0 0	0 0 0 0	0 0 0 0	0 1 2	0 0 1 3	0 0 0 0	0 0 4	1 2 1 2	0 0 1 1
Thames		0 0 0	0 1 0 1	0 1 0 0	0 2 0	1 3 1 0	1 0 0 0	0 1 0	4 8 0 1	0 0 0 0
Humber		0 2 0	0 2 0 0	0 3 0 0	7 13 0	1 3 5 0	0 3 0 0	8 18 0	1 5 6 0	1 4 2 0
Tyne		0 0 0	0 3 0 0	0 0 0 0	0 5 0	1 3 0 0	0 0 0 0	3 4 1	0 0 1 1	0 0 1 0
Dutch coast		0 1 0	0 0 0 0	0 0 0 0	0 1 1	0 1 2 1	0 1 0 0	0 1 0	0 1 1 0	1 1 2 0
Danish coast		0 0 0	0 0 0 0	0 0 0 0	0 0 2	1 0 3 0	0 0 0 0	0 2 0	0 0 0 0	0 0 1 0
Dogger		0 0 0	0 2 0 0	0 0 0 0	1 0 0	0 0 2 0	0 0 0 0	3 2 0	0 1 1 0	0 0 0 0
Skagerrak		0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 1 0	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0
Viking		0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 1	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0
N.W. Scotland		0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 1	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0

Table 14. *Returns of spurdogs tagged from M.V.* IRENE *in* 1962 (*details as in Table* 2).

		Males								Females							
	Year	1962				1963				1962				1963			
Region	Period	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Biscay		0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
W. Channel		0	0	0	3	1	0	0	0	0	1	3	1	0	1	0	0
E. Channel		1	0	0	0	8	0	0	0	0	0	1	2	1	0	0	0
Thames		2	0	0	0	2	0	0	0	3	4	1	0	1	1	0	0
Humber		1	18	11	1	0	7	5	0	0	6	4	0	0	8	3	0
Tyne		0	13	7	0	0	5	5	0	0	1	0	0	0	1	0	0
Dutch coast		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Danish coast		0	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0
Dogger		0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
N.E. Scotland		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

March to May, excluding those years in which the fish were tagged, 24% of the returns were from region E. Channel and 48% from region Thames. There was no difference in this pattern between the different releases. These returns indicate a winter movement into the English Channel and a return movement to the North Sea in the spring.

Some returns did not conform with this pattern. In 1961 two fish were recaptured in region E. Channel and another two fish in region W. Channel in the period June to August following their release off Eastbourne. From the releases in the same area in 1962 one fish was recaptured in region W. Channel in the period June to August following liberation and a further three in the subsequent period, September to November. These returns indicate that part of the stock, at least, moves westward down the English Channel during the summer months, from the area off Eastbourne. From the pattern and timing of these recaptures it is unlikely that these fish would have returned up the English Channel to enter the North Sea during the year of recapture. These recaptures represent 12% of the total recaptures for the periods to which they refer. Although there are no comparable data available on fishing effort in the English Channel and in the North Sea, and in particular there are no comparable data for fishing effort on spurdogs, the total fishing effort in the English Channel is less than that in the North Sea. Therefore the 12% recaptures in the English Channel means that more than 12% of the stock was in this area during the period.

There was also a total of seven recaptures in regions Humber, Tyne, Dutch coast, Danish coast and Dogger during the period December to February. Six of these were of fish released from M.V. *VIGILANTES* (Table 13). This indicates that part of the stock over-winters in the North Sea. There were only three returns from north of 57°00′N, and all of these came from fish released from M.V. *VIGILANTES* (Table 13). One return came from the Skagerrak, one from region N.W. Scotland, and one from region Viking.

Returns of male fish

The pattern of returns is almost identical with that shown by female fish, with only minor exceptions. There were no recaptures of male fish in the English Channel from either of the Eastbourne liberations in the six months after tagging, and comparison of the recaptures of male fish with those of female fish for the same two liberations shows that whereas the main concentration of female returns was from regions Thames and Humber, the male returns came in almost equal proportions from regions Humber and Tyne. There were two returns from the Scottish coasts, both from the Eastbourne 1961 liberation (Table 12).

Other tagging experiments

In September 1961, April 1962, and June 1962, a total of 338 spurdogs was tagged from the commercial liner M.V. *KARENZA* in the sea area off Land's End to determine whether

fish from this area migrated eastwards into the eastern Channel and southern North Sea, or northwards to the Scottish grounds. The returns are shown in Table 15, from which it would appear that these fish do not move to any considerable extent, there being recaptures of fish within a limited distance from the tagging area for all months of the year except February, March, May, October and December, which (with the exception of May) are months of bad weather for working the exposed grounds west of Cornwall. There was only one return from the southern North Sea.

Table 15. *Returns of spurdogs tagged from M.V.* KARENZA (*details as in Table* 2).

		September 1961 releases										June and April 1962 releases							
	Year	1961		1962				1963				1962			1963				
Region	Period	3	4	1	2	3	4	1	2	3	4	2	3	4	1	2	3	4	
Biscay		0	1	0	1	0	0	0	0	0	0	1	0	0	3	1	0	0	
Celtic		3	1	1	5	2	0	0	0	1	0	1	1	0	0	1	0	0	
N. Norway coast		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
W. Channel		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
Thames		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	

CONCLUSIONS

The tagging data provide clear evidence that the spurdogs supporting the north of Scotland trawl fishery and the line fishery in the southern and middle North Sea form different stocks and that for the purpose of fisheries assessments they must be treated separately. Further evidence that these fish form separate stocks came from an examination of spines taken for age determination (see Holden and Meadows, 1962). It was noticed that spines taken from fish caught in the English east coast line fishery were much easier to read than those taken from fish caught in the north of Scotland trawl fishery, due to the absence of secondary marks in the former. Three persons experienced in reading otoliths for age determination sorted spines taken from fish caught in these two fisheries into two categories, spines with regular marks and those with irregular secondary marks (Plate 1). The results are shown in Table 16 and the value of χ^2 is significant at the 0·001 level of probability. In addition to these two stocks, which it is proposed to call the Scottish-Norwegian and the Channel stocks, there is sufficient evidence to postulate the existence of a third, the Atlantic stock.

Table 16. *Comparison of spines taken from spurdogs caught north of Scotland and in the southern North Sea* (*see text*).

Area	Number of spines showing		Total	% Regular
	Regular marks	Irregular marks		
Southern North Sea	218	138	356	61·2
North of Scotland	154	223	377	40·8

$\chi^2 = 29{\cdot}6 \qquad P < 0{\cdot}001$

THE STOCKS

THE SCOTTISH-NORWEGIAN STOCK

This stock populates the sea area from west of Scotland to the Norwegian coast and supports the north of Scotland trawl fishery and the Norwegian line fishery. Aasen (1962) first described the movements of these fish and from his tagging data considered that there was a movement during the summer to the Orkney and Shetland Islands of spurdogs from the

Norwegian coast, to which they returned in the winter. He stated that 'there are some notable exceptions to this simple rule' and later (Aasen, 1963) considered that the exceptions were increasing. To some extent the distribution of returns from the English tagging experiments supports Aasen's hypothesis, but the numerous returns from the north of Scotland grounds during the winter months indicate that his hypothesis over-simplifies the facts. In particular the tag returns from the M.V. *OCEAN STAR* liberation indicate that during the summer months there is a movement to the Norwegian coast of fish which have over-wintered off the Scottish coasts.

The returns of female spurdogs from the north of Scotland liberations, and in particular those from cruise X/1961 of R.V. *CLIONE* (Table 3), show that the stock is split between the Scottish and Norwegian grounds during the months of December to February. For the same period the returns of male fish indicate that the majority of these fish have returned to the Scottish grounds after a movement during the preceding three months that has spread the stock over the whole area between Scotland and Norway. Such a distribution during December and January is anomalous with respect to the breeding cycle. The spurdog is viviparous and the pregnancy cycle takes two years (Ford, 1921; Templeman, 1944), the young being born during December and January close inshore (Hickling, 1930). Any one mature female spurdog gives birth to young only in alternate years, the whole mature female stock being equally divided between those in the first and those in the second years of pregnancy. Ovulation and fertilization occur shortly after birth of the young and, since there is no obvious sperm storage mechanism in the female fish, it is reasonable to assume that copulation occurs between birth of the young and ovulation. Female fish caught off the Norwegian coast and off the Scottish coast were therefore examined to determine whether the stock split according to the state of pregnancy, the assumption being that females near to full term remained in British waters, where the returns indicated that male fish were concentrated. The results (Table 17) show that females in both years of pregnancy were found in both areas, but there is a statistically significant predominance of females at full term in British waters (χ^2 18·0, $P < 0{\cdot}001$ for one degree of freedom). The data from the Norwegian coast indicate the reverse situation, but the ratio does not differ significantly from unity. This may be due to the small size of the sample. The results therefore do indicate that there may be some division of the mature female stock by pregnancy state at this period, but that it is not a clear-cut separation.

Table 17. *Numbers of female spurdogs in each year of pregnancy caught off the north of Scotland and off the Norwegian coast during the months November to February.*

Area	Year of pregnancy		Total	%	
	First	Second		First	Second
North of Scotland	64	123	187	34·2	65·8
Norway coast	23	18	41	56·1	43·9

The apparent absence of male fish in Norwegian waters may be due to the preferential fishing on female fish mentioned earlier. To test this hypothesis the returns of fish from west of the Greenwich meridian by Norwegian vessels for the months May to September inclusive were compared with returns from British vessels (Table 18). This shows that the ratio of tag returns, by sexes, by the latter vessels does not vary significantly from the sex ratio of the releases, whereas that of the former does, the rate of return for females being twice that for males. The Norwegian returns from east of 3 E for the months October to April were then examined (Table 19), on the assumption that the sex ratio of catches as indicated by the returns from British waters during the summer months is normal for Norwegian vessels. This showed that female fish were three and a half times as abundant as male fish in this area, the returns of the former being eight times as high as the latter.

The data therefore do indicate that it is more probable that a female fish about to give birth to young will remain in British waters rather than migrate to the Norwegian coast.

Table 18. *Comparison of returns of tagged spurdogs by British and Norwegian vessels from west of the Greenwich meridian for the months May to September inclusive; Petersen disc data only.*

		Male	Female	Total	χ^2	P
Number of fish tagged		2 238	1 954	4 192	—	—
British returns	number	18	22	40	0·83	$<0·5$ $>0·1$
	%	0·8	1·1	1·0	—	—
Norwegian returns	number	25	50	75	11·53	$<0·001$
	%	1·1	2·6	1·8	—	—

Table 19. *Returns of tagged spurdogs by Norwegian vessels from east of 3°E for the months October to April inclusive, compared with the returns by Norwegian vessels fishing in British waters in the months May to September (Table 18); Petersen disc data only.*

	Male	Female	Total
Number tagged	2 238	1 954	4 192
Number of returns	6	42	48
% return	0·3	2·1	1·15
Ratio of male to female returns	1	7	—
Ratio of male to female returns by Norwegian vessels in British waters	1	2	—

They also indicate that a higher proportion of the male stock remains in British waters than migrates to Norway. These conclusions are based solely on a statistical analysis of the data, and there exists an alternative hypothesis to account for the pattern of returns. There is evidence from observations on the position of fishing of Norwegian liners, as observed on cruise X/1961 of R.V. *CLIONE*, and from the composition of their catches, as indicated by tag returns, that the preferred habitat of mature female spurdogs is rough stony ground. These grounds are unsuitable for trawling, as a consequence of which the availability of these fish to trawlers is limited. The young are born in inshore waters, to reach which the mature female fish near full term must migrate from their preferred habitat. As a consequence of this females near full term will predominate in the trawler catches, due to their greater availability compared with that of females at mid-term. The catches of female fish on the Norwegian coast, which show almost equal numbers of fish in both years of pregnancy, would be unbiassed because the Norwegian vessels can shoot their lines irrespective of the bottom. This leaves unexplained the greater proportion of female fish in the Norwegian, coastal, winter catches. The composition of the catches of the M.V. *OCEAN STAR* suggests that in British waters shoaling by sexes is accentuated during the winter months, and presumably the behaviour of fish on the Norwegian coast will be similar. In these conditions it will be easier for the Norwegian fishermen to fish selectively shoals of female fish, resulting in an even larger proportion of returns of female fish than obtained in British waters during the summer. This latter hypothesis, that there is no differential migration of male and female fish, is more probable than the former hypothesis, which would require the minor part of the mature male stock to migrate to Norway, if those female fish that were to give birth to their young in Norwegian waters were to be fertilized, and the major part to remain in British waters. It is difficult to consider a behavioural mechanism that would permit this. The simpler hypothesis is the more probable.

The following explanation of the movements of the stock, which is considered to be consistent with the tag returns and the distribution of fishing effort on the sexes, is illustrated in Table 20. This shows the recaptures of male and female fish, by areas, for the year following liberation. All but eleven of the male fish were mature at release, but the female fish have been split into three groups, fish less than 70 cm long, fish between 70 cm and 84 cm,

Table 20. *Distribution of returns of tagged spurdogs from cruises IX and X/1960 of R.V.* SIR LANCELOT, *and cruises X and XII/1961 of R.V.* CLIONE, *by regions and by three-month periods, for the year following release; data from all tag types; returns from Skagerrak and south of 55° 30′N excluded.*

Region / Period	N.W. Scotland	N.E. Scotland	Viking	N. and S. Norway coast
	Males			
June–August	2	12	1	1
September–November	10	9	1	3
December–February	13	3	1	2
March–May	12	4	0	0
	Females less than 70 cm			
June–August	1	3	2	0
September–November	2	3	0	1
December–February	1	1	0	0
March–May	5	1	0	2
	Females 70 cm to 84 cm			
June–August	4	6	0	0
September–November	3	6	0	0
December–February	0	0	2	3
March–May	1	2	0	4
	Females 85 cm +			
June-August	8	16	0	1
September–November	5	9	0	5
December–February	3	0	0	4
March–May	4	2	1	6

and fish of 85 cm or longer. These three groups correspond to entirely immature fish, maturing (with some mature fish), and entirely mature fish (Holden and Meadows, 1964). This reduces the number of returns that can be considered, but permits an analysis of the differential movements of immature, maturing and mature female fish. The stock is mainly concentrated off the north of Scotland, Orkney and Shetland Islands from June to August (Figure 3). From September to November some of the stock moves eastward, resulting in an even distribution between the north of Scotland and the Norwegian coast. In December, January and February the mature fish move into coastal waters, either on the Scottish or on the Norwegian coast (Figure 3), with those female fish that are at full term in pregnancy moving close inshore to give birth to their young. As they move offshore again they meet with the male fish and copulation occurs, or alternatively the male fish also move close in, a more probable hypothesis because few female fish are caught in the North Minch. During the months of December to February the returns of immature and maturing fish, although only six in number, came from over the whole sea area between Scotland and Norway, in contrast to the mature female fish, returns of which were absent from 4°W to 4 E. From May onwards those fish that migrated to the Norwegian coast move westward to meet with those that remained in Scottish waters during the winter.

The only returns that do not fit this hypothesis are those from cruise II/1962 of R.V. *ERNEST HOLT* (Table 8). During the three months after tagging (June, July and August) all but one of the returns came from the Norwegian coast. Similar results were obtained by Aasen (1963). During 1962 the fishery was anomalous in that there was a scarcity of spurdogs on the Scottish grounds (Anon., 1962a) and large catches of fish were taken off the south-east coast of Norway (Anon., 1962b). There is some evidence that a change may be occurring

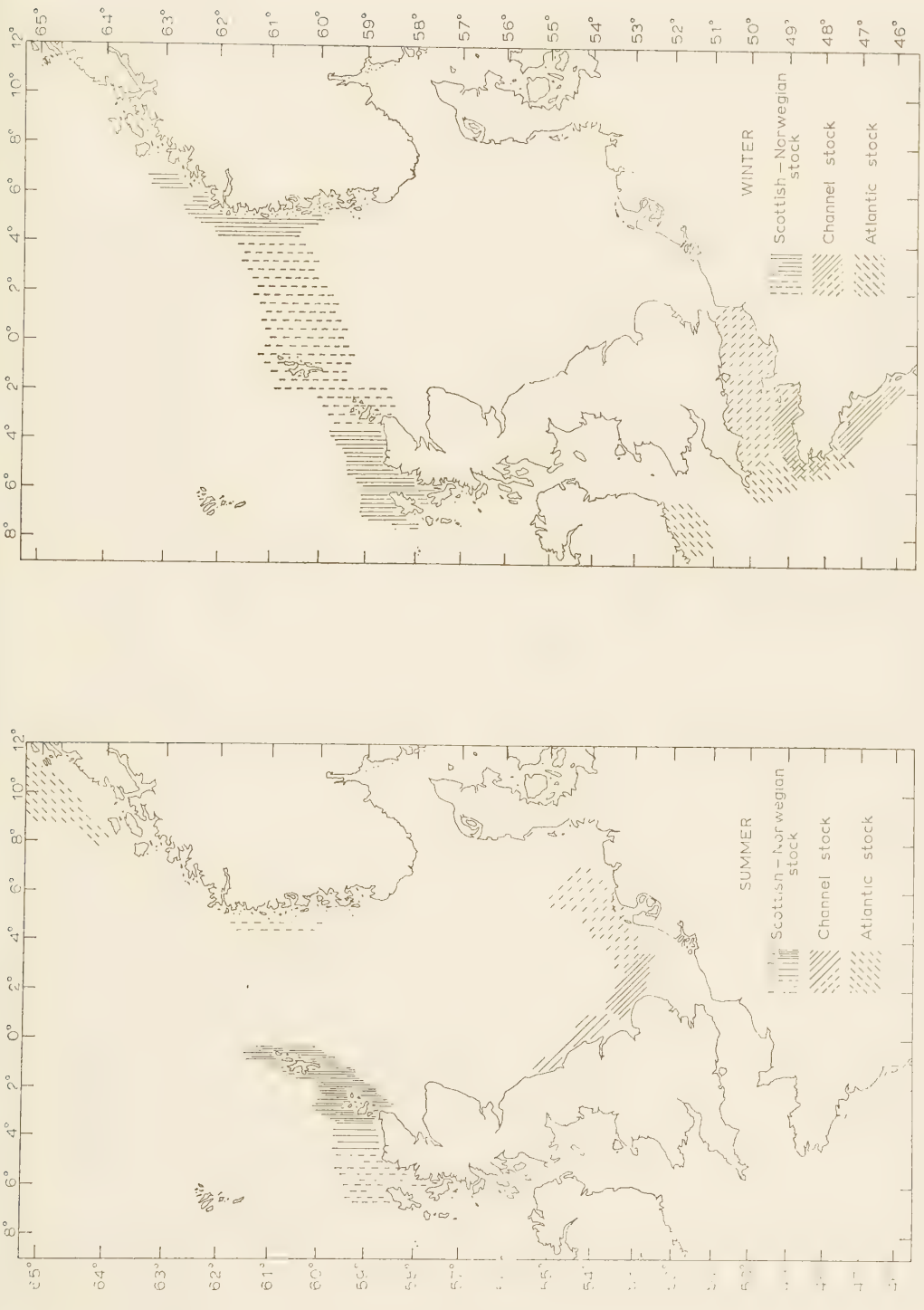

Fig. 3. *The winter and summer distribution of the Scottish-Norwegian, Channel and Atlantic stocks of spurdogs, as indicated by tag returns. Intensity of shading indicates probable abundance but is not proportional to number of tags returned.*

in the migratory movements of this stock, because an unusual line fishery was reported in Oslofjord in 1963 (Anon., 1963b).

The complete separation of this stock from the Channel stock is shown by the fact that despite the large numbers of fish, approximately 16 000, tagged by both the Norwegians and the English from the Scottish-Norwegian stock, none of them were recaptured in the Grimsby line fishery. Within the North Sea there have been no recaptures south of 56°30′N.

THE CHANNEL STOCK

The main over-wintering area of this stock is the English Channel, with some fish moving as far south as the Bay of Biscay (Figure 3). During the spring the stock moves eastward along the Channel, entering the North Sea from approximately April onwards. There is a return migration during the late autumn and winter. As with the Scottish-Norwegian stock all the returns do not fit a simple pattern of movement, some fish being recaptured in the Channel during the summer, others being recaptured in the North Sea during the winter. Examination of the recaptures of spurdogs by Grimsby and Lowestoft trawlers (Table 21), whose catches represent a random sample of spurdogs because they are fishing for other species, confirms, however, that this movement into the North Sea is in the main a summer one and that any returns during the winter months can be considered as stragglers from the main stock. The returns by Lowestoft trawlers in September and October would be expected

Table 21. *Recaptures of tagged spurdogs by Grimsby trawlers fishing in the middle North Sea (Region IVB) and Lowestoft trawlers fishing in the southern North Sea (Region IVC), steam and motor vessels combined. V = M.V.* VIGILANTES, *E61 = Eastbourne* 1961, *and E62 = Eastbourne* 1962 *releases. Recaptures during* 1961 *from M.V.* VIGILANTES *liberation not included (see text).*

Year and month	Grimsby trawlers in Region IVB						Lowestoft trawlers in Region IVC					
	Returns from				Hours fishing	Tags/ 10 000 hr	Returns from				Hours fishing	Tags/ 10 000 hr
	V	E61	E62	Total			V	E61	E62	Total		
1961												
June	–	1	–	1	15 924	0·63	–	0	–	0	4 454	0·00
July	–	3	–	3	14 242	2·11	–	0	–	0	2 596	0·00
Aug.	–	3	–	3	17 337	1·73	–	0	–	0	3 792	0·00
Sept.	–	5	–	5	21 334	2·34	–	0	–	0	3 422	0·00
Oct.	–	3	–	3	18 998	1·58	–	0	–	0	2 301	0·00
Nov.	–	0	–	0	16 028	0·00	–	0	–	0	3 437	0·00
Dec.	–	0	–	0	17 935	0·00	–	0	–	0	2 927	0·00
1962												
Jan.	1	0	–	1	17 844	0·56	0	0	–	0	3 922	0·00
Feb.–May	0	0	–	0	60 944	0·00	0	0	–	0	6 959	0·00
June	0	0	1	1	10 585	0·94	0	0	0	0	1 912	0·00
July	0	0	0	0	14 432	0·00	0	0	0	0	2 473	0·00
Aug.	3	3	1	7	16 892	4·14	0	0	0	0	1 981	0·00
Sept.	1	1	2	4	15 364	2·60	1	0	0	1	1 666	6·00
Oct.	1	0	2	3	20 057	1·50	1	0	1	2	2 663	7·51
Nov.	1	0	1	2	14 818	1·35	0	0	0	0	2 270	0·00
Dec.	1	0	0	1	14 748	0·68	0	0	0	0	1 823	0·00
1963												
Jan.	0	0	0	0	20 126	0·00	2	0	0	2	3 200	6·25
Feb.–July	0	0	0	0	107 048	0·00	0	0	0	0	20 499	0·00
Aug.	0	0	1	1	15 196	0·66	0	1	1	2	1 568	12·76
Sept.	0	0	0	0	15 391	0·00	0	0	0	0	1 367	0·00
Oct.	0	0	0	0	15 695	0·00	1	0	0	1	994	10·06
Nov.	0	0	0	0	14 386	0·00	0	0	0	0	3 937	0·00
Dec.	0	0	0	0	18 032	0·00	0	0	0	0	2 324	0·00

if there were a southward movement at this time, although there is no corresponding increase in the return rate in May and June when the northward migration occurs. The returns during 1961 from the M.V. *VIGILANTES* liberation have been omitted from Table 21 because they were released in the area in which the trawlers were working. It would appear that some fish do leave the Channel stock and join the Scottish-Norwegian stock, as evidenced by the recapture of three Channel-tagged fish north of 59°N. Apart from one return from the Eastbourne 1961 liberation (Table 12) there is no evidence that this stock enters the Irish Sea.

THE ATLANTIC STOCK

The recaptures in regions Biscay and Celtic of fish tagged off the north of Scotland are not consistent with the general pattern of migration shown by the majority of recaptures of fish tagged in this area. From cruise X/1961 of R.V. *CLIONE* there were eight returns from south of 55°30′N (Table 3), and from cruise XII/1961 there were a further three (Table 4). It appeared possible that these fish represented stragglers from the main Scottish-Norwegian stock, but examination of Holden's (1962) returns of spurdogs tagged in the Irish Sea indicated that they might form part of a separate stock. Holden (*op. cit.*) tagged a total of 278 spurdogs in the Irish Sea in the years 1957, 1958 and 1959, all three liberations being made in the months November and December. The results have been summarized in Table 22, which includes those returns received since publication of the earlier recaptures. Although

Table 22. *Returns of tagged spurdogs from the three releases in the Irish Sea (details as in Table 2); R.V.* PLATESSA *cruises XVIII/*1957, *XVII/*1958 *and XXI/*1959.

		1957 release (32 fish)			1958 release (145 fish)				1959 release (101 fish)		
	Year	1957	1958	1962	1958	1959	1960	1961	1959	1960	1961
Region	Period	4	1 2 3 4	1 2 3 4	4	1 2 3 4	1 2 3 4	1 2 3 4	4	1 2 3 4	1 2 3 4
Biscay		2	0 0 0 0	0 0 0 0	1	0 0 0 0	0 0 0 0	0 0 1 0	0	0 0 0 0	0 0 0 0
Celtic		0	0 0 0 0	0 0 0 0	2	0 0 0 0	0 0 0 0	0 1 0 2	1	0 0 0 0	0 1 0 0
N.W. Scotland		0	0 0 0 0	0 0 0 0	0	0 0 2 0	0 0 1 0	0 0 0 0	1	0 0 1 2	0 0 0 0
N.E. Scotland		0	0 1 0 0	0 0 0 0	0	0 0 0 0	0 0 0 0	0 0 0 0	0	1 0 0 0	0 0 0 0
Skagerrak		0	0 0 0 0	0 0 1 0	0	0 0 0 0	0 0 0 0	0 0 0 0	0	0 0 0 0	0 0 0 0

there were returns from the north of Scotland fishery it is noteworthy that up to three years after release these fish were being recaptured within region Celtic during the period December to February. Recaptures would be expected in this area at this time if these fish were part of a separate stock that regularly migrated through the Irish Sea during the winter months. The pattern of returns is not inconsistent with the hypothesis that there is a stock of spurdogs that winters in region Biscay and migrates northward in the summer. Further evidence for this hypothesis is that of the 278 spurdogs tagged with Petersen discs in the Irish Sea, five (1·8%), excluding those recaptured in the year following release, were returned from regions Celtic and Biscay, whereas of 4 192 fish tagged with Petersen discs on the north of Scotland grounds only eight fish (0·2%) were recaptured in these two regions. If the fish tagged around the north of Scotland were from the same stock as the Irish Sea liberations, approximately 75 returns might have been expected from regions Celtic and Biscay.

Examination of the eight returns from these two regions of fish tagged from cruise X/1961 of R.V. *CLIONE* showed that five came from an area bounded by the latitudes 60°00′N and 60°06′N and by the longitudes 03°33′W and 03°38′W, and were released either on 3 June 1961 or 7 June 1961. They represented 2·9% of the 175 fish released in this area on these two days. If the fish in this region had been representative of the whole stock then 83 returns might have been expected from the remainder of the fish tagged. There were only

three. Similarly, of the three returns from cruise XII/1961 of R.V. *CLIONE* two fish had been released on the same day at nearly the same position, the total number of releases in this area being eleven fish. The majority of the returns from the two regions Biscay and Celtic were consistent with a southward winter movement, as shown by the spurdogs released in the Irish Sea. Of the eleven fish recaptured in these two regions six were caught during the period December to February and two during the months of March to May (Tables 3 and 4).

The Norwegian recaptures also show a southward movement by some fish and these came from a limited number of releases. Aasen (1962, 1963) describes the recaptures from nine tagging experiments. From only two of these were fish recaptured south of 55°30′N. From his experiment 1, when 1 000 fish were released north of Scotland in November 1958, there was one recapture in December 1960 off south-west Ireland, and from his experiment 8, when a further 1 000 tagged fish were released off the Orkney and Shetland Islands in October-November 1961, there were two recaptures west of Ireland. Of the remaining 1 968 fish released on the north of Scotland grounds in three experiments there were no recaptures south of 55°30′N and none from 3 208 fish released off the Norwegian coast (six experiments).

The returns from the two regions Celtic and Biscay of fish released both in the Irish Sea and north of Scotland cannot be easily explained if these fish are considered as stragglers from the Scottish-Norwegian stock. The recaptures from the north of Scotland came from a limited number of releases, and the fish tagged in the Irish Sea were recaptured in the same area up to three years later. Both these facts indicate that a separate stock is involved and it is proposed to call this the Atlantic stock. Its winter, southern limit is in the regions Celtic and Biscay (Figure 3). During the spring it migrates northward both to the west of Ireland and through the Irish Sea to the north of Scotland where it mixes with the Scottish-Norwegian stock. The existence of two stocks of the same species, occurring on the same grounds at the same time of the year but separating for the remainder of the year, is not unique. The Norwegian coastal cod and the Barents Sea cod spawn in the same area but otherwise do not intermingle, and the results of spurdog tagging by Holland (1957) indicate that there are two stocks off the Pacific coast of the United States of America, one making a limited north-south migration and the other, an offshore stock, a much more extensive movement. It is possible that the summer northern limit of the Atlantic stock may be as far north as the Barents Sea (Figure 3). Aasen (1962) records one return from south of the Lofoten Islands in August 1960 and a second from the Barents Sea in June 1959. This latter fish was liberated in the same position as the one fish recaptured off S.W. Ireland.

OTHER STOCKS

Although it is not possible to postulate definitely the existence of other stocks, it is evident that the returns obtained from the M.V. *KARENZA* liberations do not fit in with any of the above three stocks, and it appears possible that there exists yet a fourth stock of fish to the south and west of Ireland, upon which Hickling (1930) made his observations.

There is also the possibility that coastal stocks of spurdogs exist. In July 1962 sixty-seven fish were tagged from R.V. *TELLINA* in Scottish lochs, and none of these have been recaptured. This evidence is inconclusive, and Aasen (1962, 1963) considers that the spurdogs caught in the Norwegian fjords are strays from the main Scottish-Norwegian stock.

DISCUSSION

ALTHOUGH the tagging results presented here confirm the existence of a Scottish-Norwegian stock, termed by Aasen (1962) the north-east Atlantic stock, they show that this stock makes a more complex migration than the summer movement to the Scottish grounds and winter movement to the Norwegian coast suggested by him. The lack of fishing for spurdogs

in region Viking during the winter precludes the possibility of stating definitely whether there is an almost total split in the stock between Scotland and Norway, or whether the stock is spread over the entire area with only the mature stock found close inshore, but the latter explanation is the more likely on the available data.

The results conclusively show that at least two stocks of spurdogs are fished by English vessels. They also indicate that in region Biscay a very complex mixing of stocks may occur, with fish from the Channel and Atlantic stocks mingling with a non-migratory stock, as indicated by the M.V. *KARENZA* liberations. More work is required to determine whether some of the stocks postulated as occurring in this region do in fact exist.

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SUMMARY

1. A series of tagging experiments on spurdogs is described and the results detailed. These show that the fish supporting an English east coast line fishery are separate from those that support a British trawl fishery and a Norwegian line fishery off the north of Scotland. These stocks are called the Channel and Scottish-Norwegian stocks.

2. The tag returns also indicate the existence of an Atlantic stock, and possibly of a southern Ireland stock.

3. The movements of the three named stocks are described. The Channel stock overwinters in the English Channel and migrates into the Southern Bight during the summer. The Scottish-Norwegian stock occupies the sea area between Scotland and Norway during the winter but is mainly concentrated around the Shetland and Orkney Islands during the summer. The Atlantic stock is considered to over-winter off the Brittany coast or further south and to migrate north, possibly as far as the Barents Sea, in the summer.

REFERENCES

AASEN, O. (1961). Pigghåundersøkelsene. *Fiskets Gang*, Årg. **47**: 36–44.

AASEN, O. (1962). Norske pigghåmerkninger 1958–61. *Fisk. og Hav.*, 1962, Nr. **3**: 1–5.

AASEN, O. (1963). Norske pigghåmerkninger 1962. *Fisk. og Hav.*, 1963, Nr. **2**: 10–15.

ANON. (1952). Ministry of Agriculture and Fisheries sea fisheries statistical tables 1951. 36 pp. H.M.S.O. Lond.

ANON. (1962a). Fiskerioversikt for uken som endte 28. juli 1962. *Fiskets Gang*, Årg. **48**: 433–437.

ANON. (1962b). Fiskerioversikt for uken som endte 22. september 1962. *Fiskets Gang*, Årg. **48**: 529–533.

ANON. (1963a). Ministry of Agriculture, Fisheries and Food sea fisheries statistical tables 1962. 43 pp. H.M.S.O. Lond.

ANON. (1963b). Fiskerioversikt for uken som endte 24. august 1963. *Fiskets Gang*, Årg. **49**: 495–502.

FORD, E. (1921). A contribution to our knowledge of the life-histories of the dogfishes landed at Plymouth. *J. mar. biol. Ass. U.K.*, **12**: 468–505.

HICKLING, C. F. (1930). A contribution towards the life-history of the spurdog. *J. mar. biol. Ass. U.K.*, **16**: 529–576.

HOLDEN, M. J. (1962). English spurdogfish tagging. *Annls biol.*, Copenh., **17**: 107–108.

HOLDEN, M. J. and MEADOWS, P. S. (1962). The structure of the spine of the spurdogfish (*Squalus acanthias* L.) and its use for age determination. *J. mar. biol. Ass. U.K.*, **42**: 179–197.

HOLDEN, M. J. and MEADOWS, P. S. (1964). The fecundity of the spurdog (*Squalus acanthias* L.). *J. Cons. int. Explor. Mer.*, **28**: 418–424.

HOLLAND, G. A. (1957). Migration and growth of the dogfish shark, *Squalus acanthias* (Linnaeus), of the eastern North Pacific. *Fish. Res. Pap. Wash. Dep. Fish.*, **2** (1): 43–59.

KAUFMANN, D. E. (1955). Noteworthy recoveries of tagged dogfish. *Fish. Res. Pap. Wash. Dep. Fish.*, **1** (3): 39–40.

TEMPLEMAN, W. (1944). The life-history of the spiny dogfish (*Squalus acanthias*), and the vitamin A values of dogfish liver oil. *Res. Bull. Div. Fish. Resour. Newfoundld*, No. 15. (102 pp.).

TEMPLEMAN, W. (1958). Grand Bank tagged dogfish moves to Iceland. *Progr. Rep. Atl. biol. Sta.*, No. 70: 28–30.

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